LOW MINIMUM TEMPERATURES IN NORTH CENTRAL UNITED STATES, JULY 13, AND 14, 1950

CHARLES M. LENNAHAN AND LEWIS C. NORTON
WBAN Analysis Center, U. S. Weather Bureau
Washington, D. C.

INTRODUCTION

Unusually low temperatures occurred over the north central United States on July 13 and 14, 1950, with minima at some points equal to or below the lowest ever recorded during the month of July. They were the result of southward flow of cold air in the wake of a depression which moved across extreme southern Canada, the cooling being intensified by nighttime radiation in an extensive High which built up over the western Plains and North Central States. A feature of the synoptic situation, beginning some 5 days before the low temperature occurred, was the movement of an upper level pressure trough eastward from the Pacific across southern Canada and the northern United States, the trough deepening markedly along with strong southward flow of cold air on the 12th and 13th.

SYNOPTIC CONDITIONS PRECEDING THE LOW TEMPERATURES

On July 8, a deep surface Low which had been moving eastward across the Pacific, was centered along the British Columbia coast and had begun to fill. By the 10th this surface Low had filled, but the upper Low at the 700-mb. level, while also filling, had maintained its identity and had continued to move slowly eastward. The position of the upper Low at 2200 EST on the 9th, off northern Vancouver Island, may be seen in figure 1.

On the 8th, colder air south of the surface Low began moving into western Washington and Oregon. It progressed eastward ahead of the upper Low, the upper Low marking roughly the center of the dome or tongue of colder air to the rear of the surface front. This surface cold front was later identified with developments accompanying the cold air outbreak over the northern Plains area, though the low temperatures occurred mainly in continental air.

Figure 2, for 2200 EST on the 10th, shows the upper level Low over British Columbia. It had moved eastward and filled slightly in 24 hours. Thereafter, it moved more rapidly eastward and deepened somewhat, being centered over Manitoba at 2200 EST on the 11th (fig. 3).

It is of interest to note the position of the tropopause at this time as indicated in figure 4. This figure shows the intersection of the tropopause with the 200-mb. level, the stratosphere being lower to the north and higher to the south of the intersection. At 2200 EST on the 11th, the intersection was bulged northward over Manitoba and western Ontario in accordance with the usual association of warm air with a high stratosphere. Over Montana the

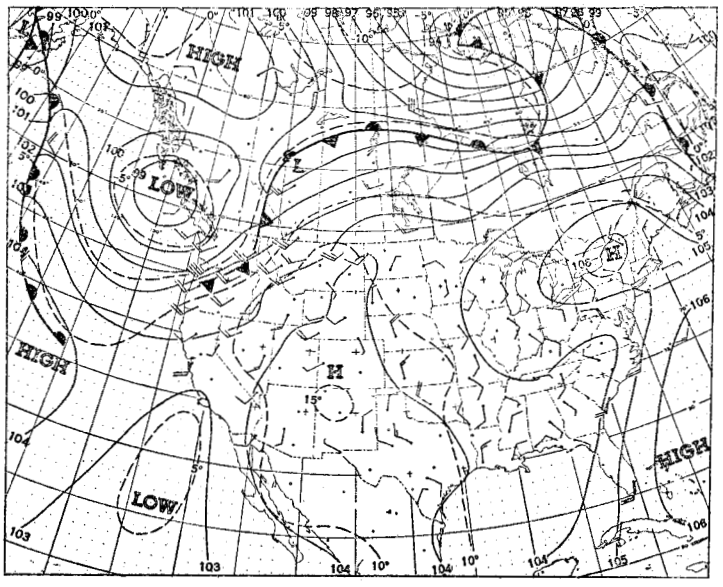

FIGURE 1.—700-mb. chart for 2200 EST, July 9, 1950. Contours (solid lines) at 100-foot intervals are labeled in hundreds of geopotential feet. Isotherms (dashed lines) are drawn for intervals of 5° C. Barbs on wind shafts are for wind speeds in knots (full barb for every 10 knots, half barb for every 5 knots, and pennant for every 50 knots).

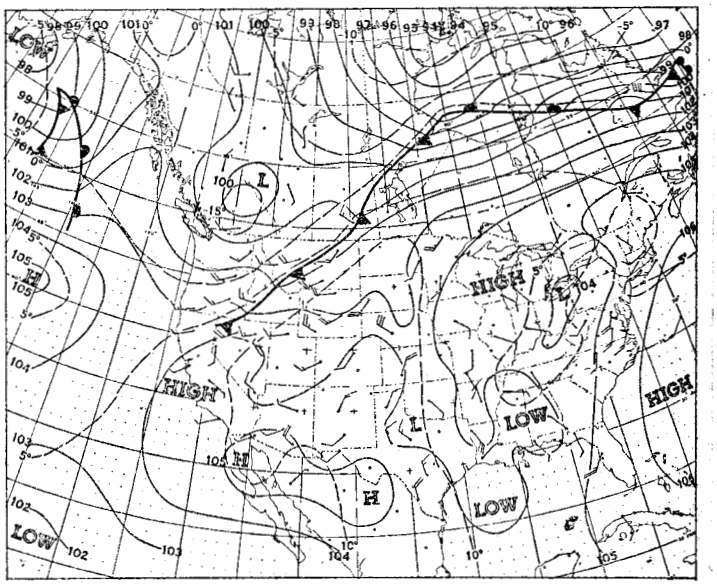

FIGURE 2.—700-mb. chart for 2200 EST, July 10, 1950.

intersection was pushing southward along with southward movement of cold air which may be seen at the 700-mb. level in figure 3. Subsequent changes in the configuration of the tropopause intersection are indicated in figure 4 at 24-hour intervals as the cold air progressed farther southward into the north central United States.

Figure 5 shows surface conditions at 0130 EST on the 11th, corresponding approximately in time to figure 2. The surface cold front had then reached the western Dakotas and colder continental air had begun to flow southward from the area west of Hudson Bay where, in turn, still colder air was being fed southward around a deep Low near the northern end of the bay. There was a weak Low along the front in the western Dakotas, and while it had not yet deepened appreciably, there had been an increase of pressure difference (previous surface charts not shown) between its center and the Rockies accompanying the increased southward flow of cold air into Montana.

The long north-south streamline from north of Hudson Bay to Montana, as indicated by the isobars in figure 5, provided some hint at that stage that the cold air north of the bay would later sweep southward into the central United States. While the cold front through the western Dakotas originally marked the leading edge of colder air from the Pacific, there was no clear demarcation, at the time of figure 5, between the maritime air and the colder continental air tending to replace it as the southward flow out of Canada was established.

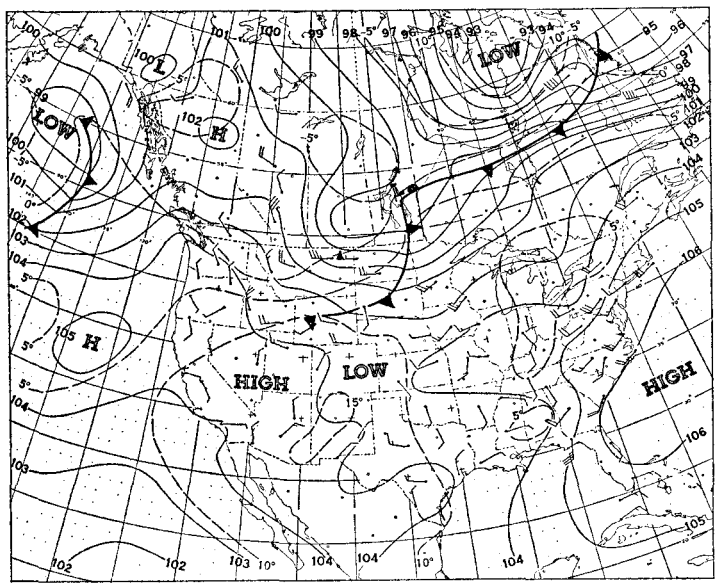

FIGURE 3.—700-mb. chart for 2200 EST, July 11, 1950.

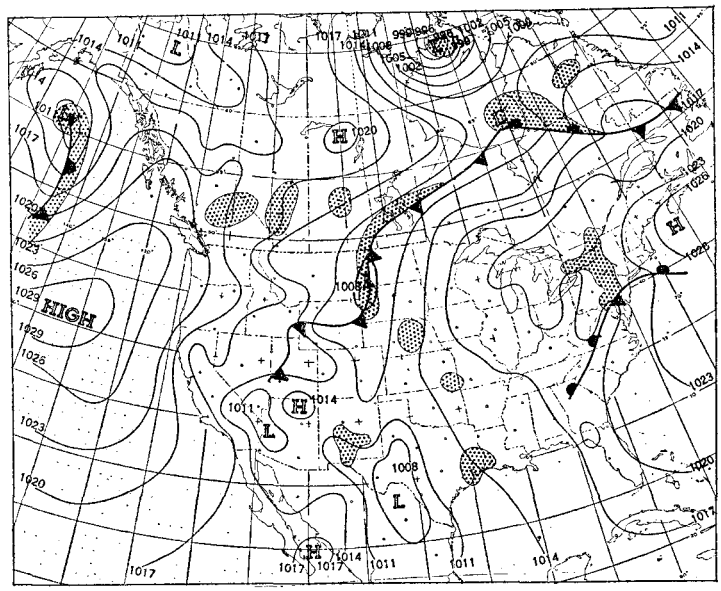

FIGURE 5.—Surface weather chart for 0130 EST, July 11, 1950. Shading indicates areas of active precipitation.

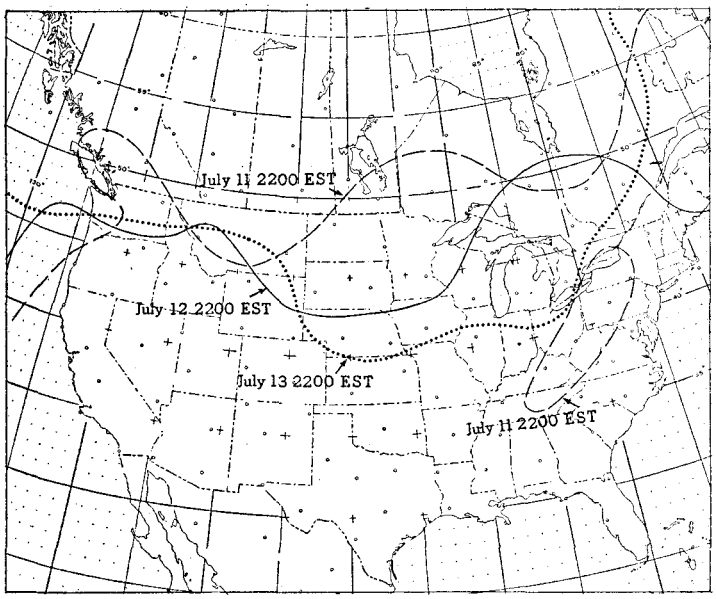

FIGURE 4.—Tropopause chart showing three positions of the intersection of the tropopause and the 200-mb. surface.

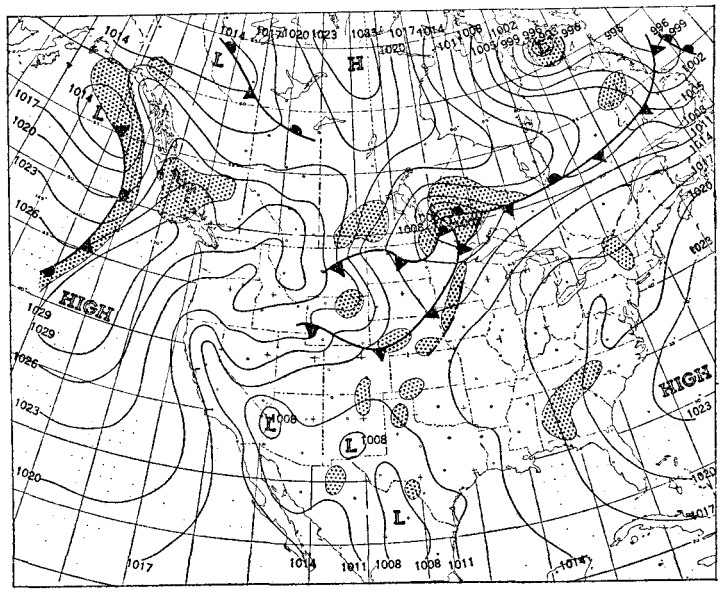

FIGURE 6.—Surface weather chart for 0130 EST, July 12, 1950. Shading indicates areas of active precipitation.

903939—50——2

On the 11th, the surface wave along the cold front deepened along with intensified southward flow of cold air, its deepening perhaps accentuated by the accelerated eastward movement of the upper level Low. By the morning of the 12th (fig. 6) the surface Low was over extreme western Ontario with a central isobar of 1002 mb. The pressure difference between its center and the Continental Divide to the west had increased to over 25 mb. This large pressure difference was sufficient to insure that a substantial amount of colder air would flow into the northwestern Plains States, and later into the North Central States as the Low moved eastward. Another significant feature at that time (fig. 6) was the appearance of a high pressure ridge in southern Alberta and western Montana. It appeared to be an offshoot of the Pacific High, but actually marked the beginning of a continental anticyclone which developed to the rear of the cold front as the Low over Ontario and its attendant frontal system moved eastward.

Figure 7, which contains the soundings at Great Falls, Mont., for 2200 EST on the 10th and 1000 EST on the 11th, shows the marked cooling which took place at higher levels well after passage of the cold front from the Pacific. This cooling aloft was necessarily from the Pacific because trajectories at the higher levels were from a westerly direction. This meant that to the east of Great Falls cooling at low levels by the southward flow of continental air was being augmented aloft by cooler air off the Pacific, insuring that the cold outbreak would extend to great depths and thus not be subject to as much warming at the surface by insolation as would be the case with a shallow layer of cold air. This cooling aloft was also associated with arrival of the upper level cold trough as may be seen by inspection of figures 2 and 3.

Figure 8 shows two soundings at Bismarck, N. Dak., on the 12th, both taken after arrival of the cold air at both low and high levels. Because of the combination of low and high level cooling the first sounding, at 1000 EST, shows no typical frontal inversion or stable layer as would be expected with passage of a conventional front. At 2200 EST, however, there was an inversion near the 650-mb. level and a dry adiabatic lapse rate from the 735-mb. level downward to near the surface. The steep lapse rate indicates that the stable layers were mainly the result of day-

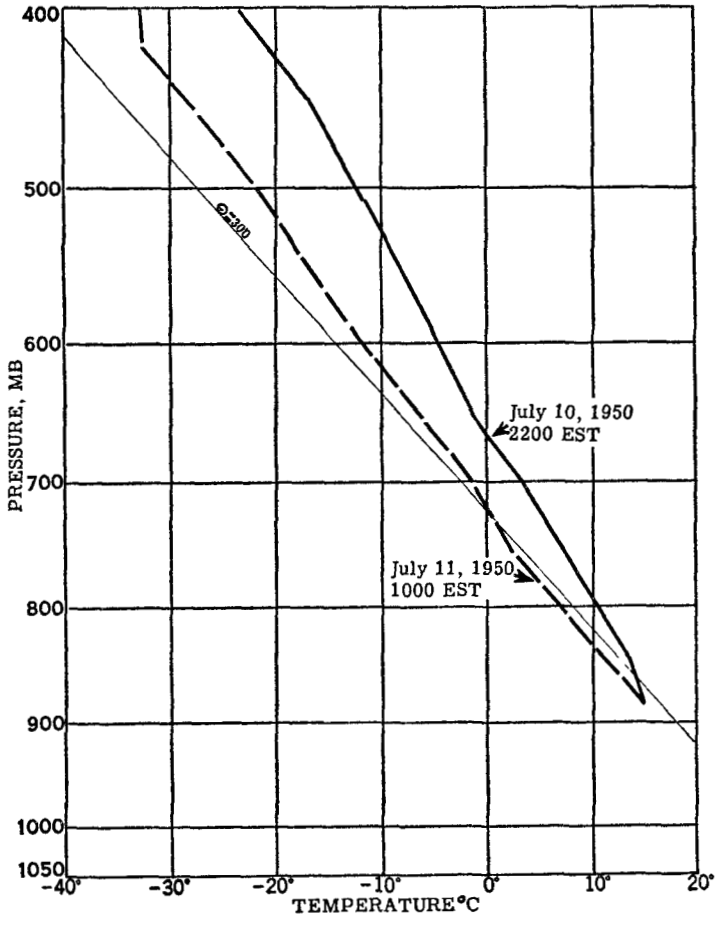

FIGURE 7.—Upper air soundings over Great Falls, Mont., plotted on a pseudo-adiabatic chart

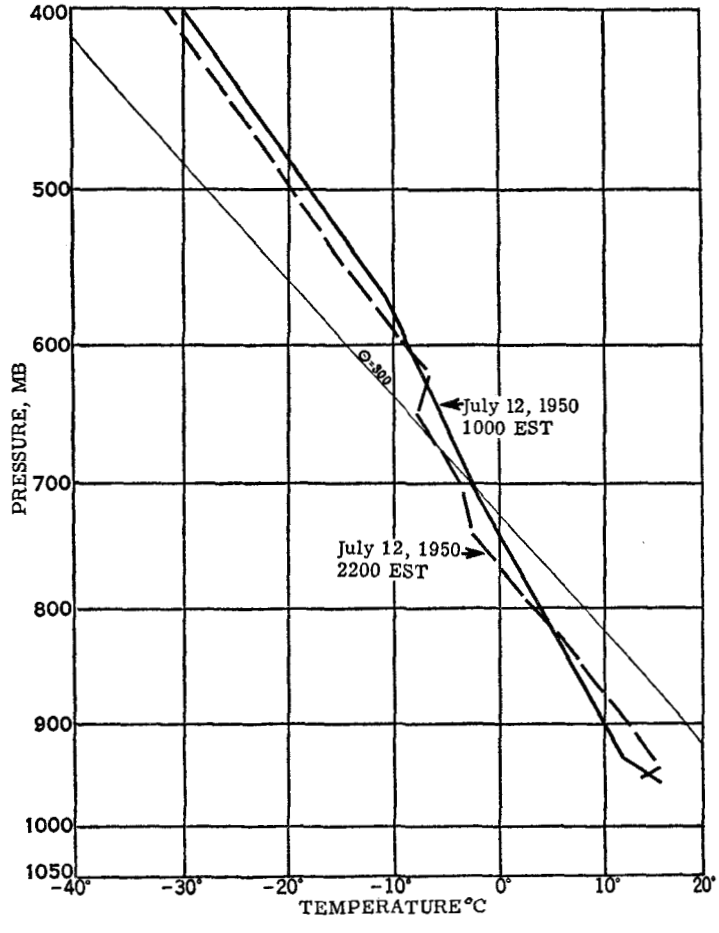

FIGURE 8.—Upper air soundings over Bismarck, N. Dak.

time turbulence, possibly accompanied by some subsidence at higher levels, though there was a slight net cooling above the stable layers. The depth of the turbulence layer was sufficient to allow only slow warming of the lower air by daytime heating during its southward movement.

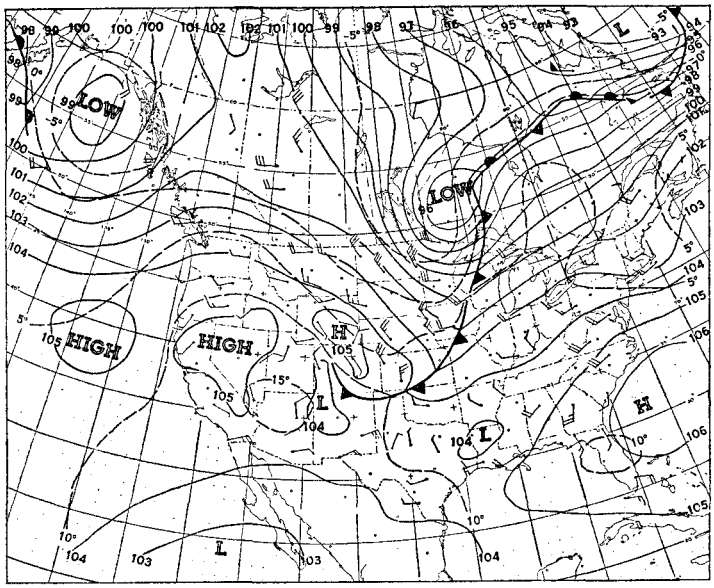

FIGURE 9.—700-mb. chart for 2200 EST, July 12, 1950.

An examination of the 700-mb. chart for 2200 EST of the 12th (fig. 9) shows that, at that level, Bismarck was near the confluence of airflows from the Pacific and from northern Canada. Temperatures aloft, where the airflow at 700 mb. was from the north, are illustrated by soundings from The Pas, Manitoba at 1000 EST on the 12th and Churchill, Manitoba, at 2200 EST on the 11th (fig. 10). The succession of temperature changes aloft at two northern United States stations are represented in figures 11 and 12 by soundings at 12 hour intervals at International Falls, Minn., and Sault Ste. Marie, Mich. The first sounding in each case was taken just prior to arrival of the colder air.

CONDITIONS DURING THE PERIOD OF LOW TEMPERATURES

On the 12th, the cold air outflow covered all the northern Plains States from the Great Lakes to the Rockies and extended southward into the Texas Panhandle, as shown in figure 13, the surface chart for 0130 EST of the 13th. The High, which in figure 6 (24 hours earlier) was barely discernible over western Montana and southern Alberta, developed rapidly on the 12th and in figure 13 covers the

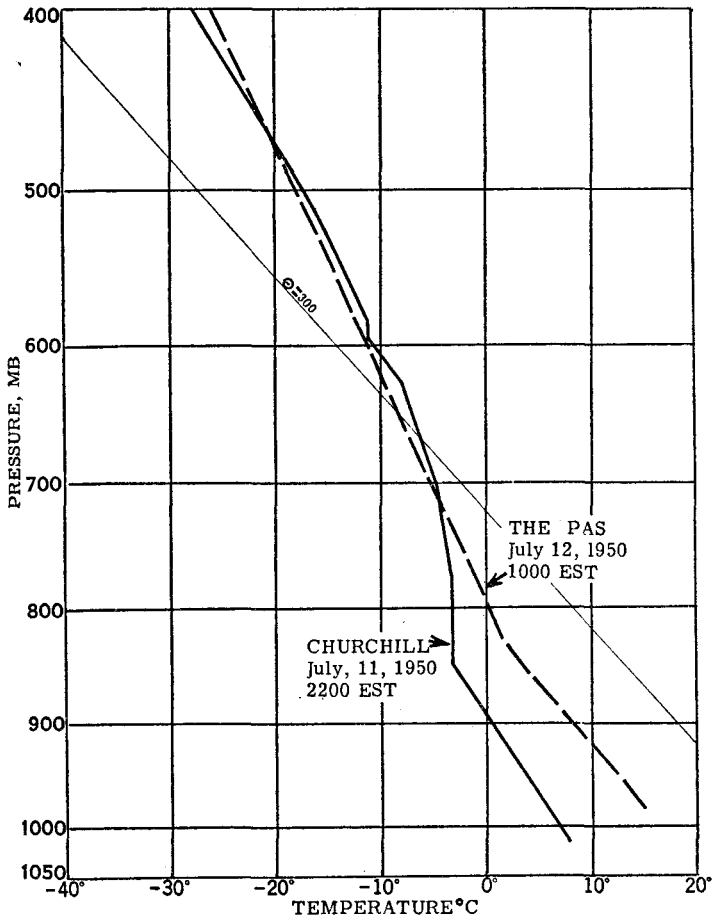

FIGURE 10.—Upper air soundings over The Pas and Churchill, Manitoba.

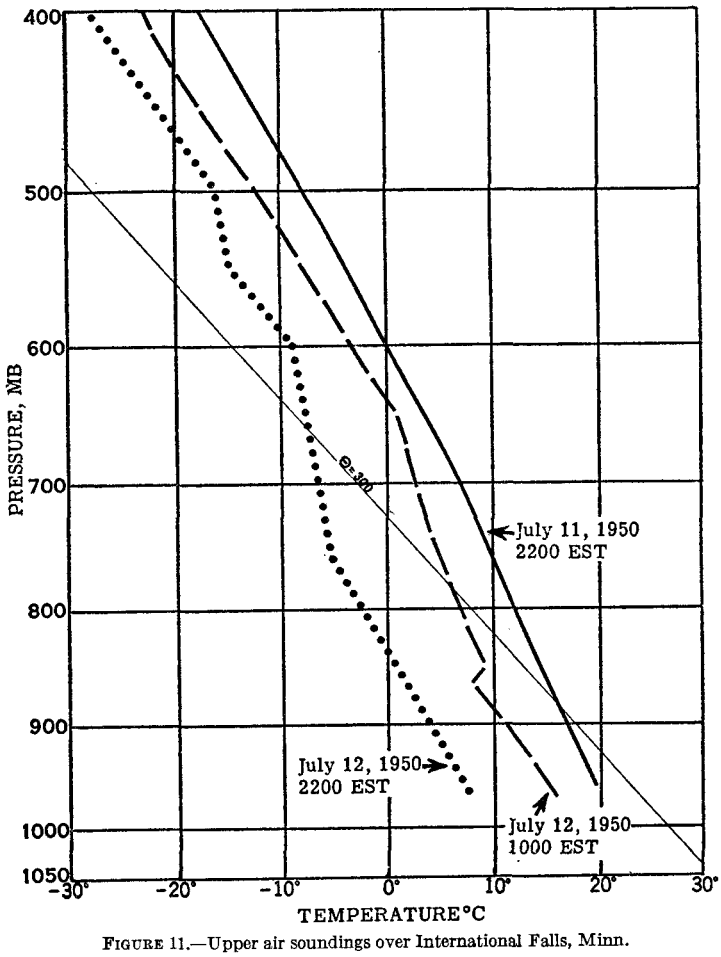

FIGURE 11.—Upper air soundings over International Falls, Minn.

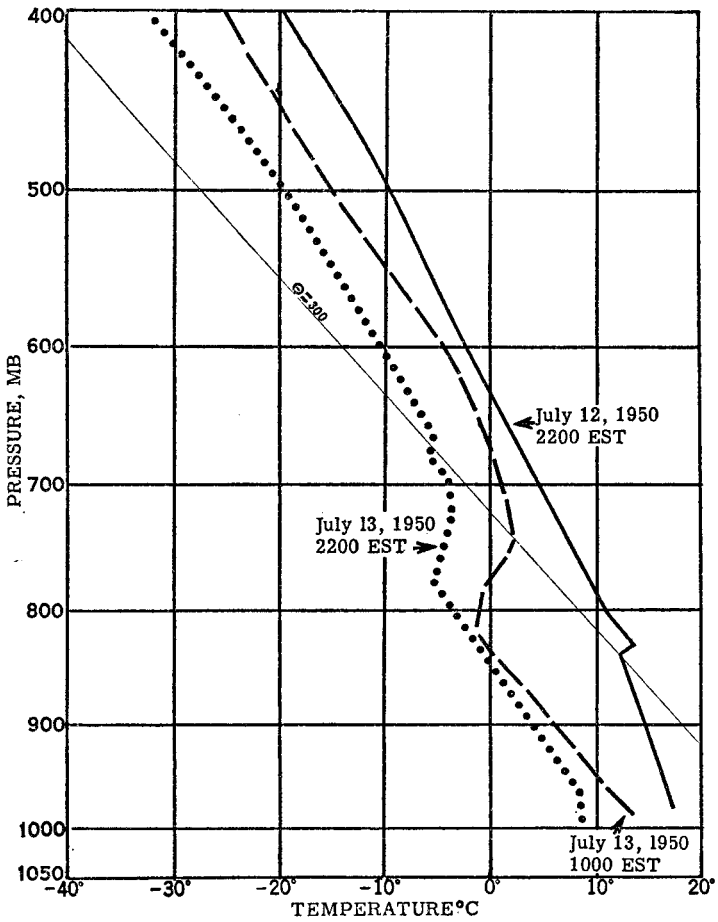

FIGURE 12.—Upper air soundings over Sault Ste. Marie, Mich.

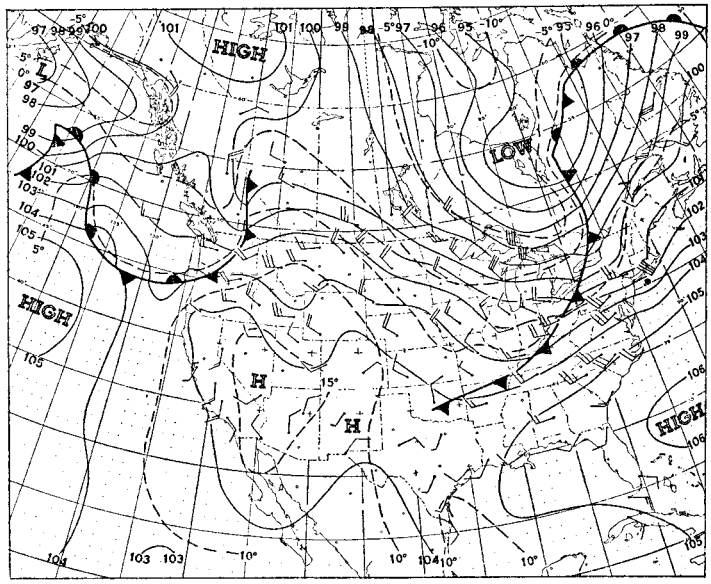

FIGURE 14.—700-mb. chart for 2200 EST, July 13, 1950.

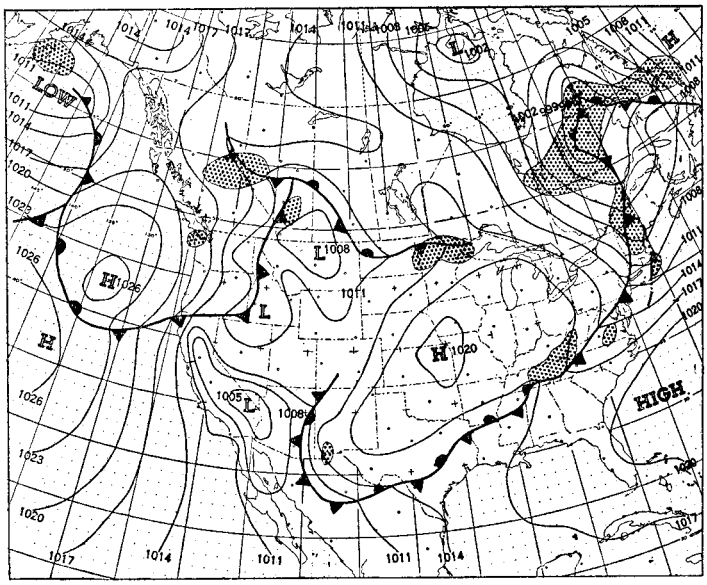

FIGURE 15.—Surface weather chart for 0130 EST, July 14, 1950. Shading indicates areas of active precipitation.

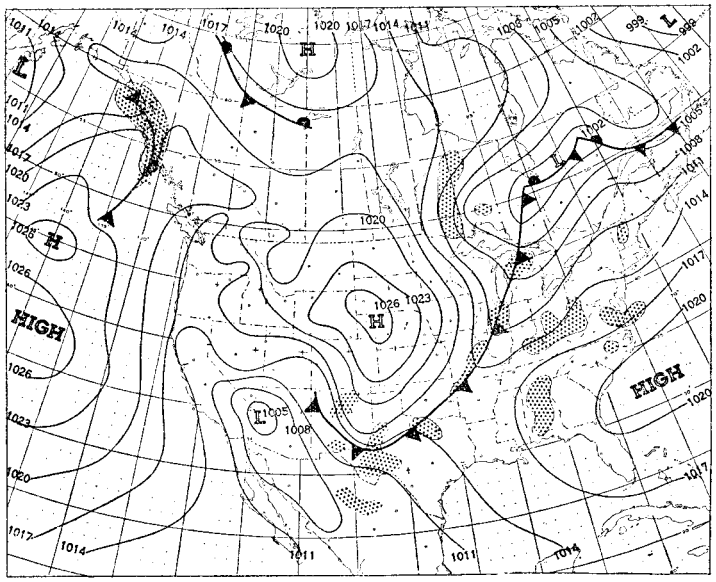

FIGURE 13.—Surface weather chart for 0130 EST, July 13, 1950. Shading indicates areas of active precipitation.

northern and central Plains region and most of the east slope of the Rockies.

Radiation within this High contributed toward low morning temperatures in the Dakotas, Nebraska, and most of Kansas on the morning of the 13th, where the lowest temperatures of the cold spell were reached on that date. The lowest temperatures of the cold outbreak were also recorded on the 13th in northwestern Michigan, northern Wisconsin, Minnesota, and western Iowa, but in these areas the low-level wind flow was strong and the reduction of surface temperatures was to a greater extent the result of rapid southward advection of colder air.

On the 13th, warmer air began to move in aloft over the northwestern Plains States, indicating a probable trend toward higher minimum temperatures over that area by the morning of the 14th. This advection of warmer air aloft is shown in figure 14, the 700-mb. chart for 2200 EST on the 13th, where transport of warmer air is indicated west of a line through northeastern Minnesota and central Iowa.

On the morning of the 14th (fig. 15), the High had become more extensive and was centered near Kansas City. Pressure gradient within it was weak over a large area, and conditions were especially favorable in the northern half of the anticyclone for low temperatures because of the combined effect of radiation and the existence of an already cold air mass. The lowest temperatures of the cold outbreak were recorded on this morning from southern Wisconsin, eastern Iowa, and Missouri, eastward through Ohio.

Figure 16 shows the minimum temperatures reported at selected locations in the northern Plains and North Central States on both the 13th and 14th, also the previous lowest temperature ever recorded at each place. It will be seen that record or near record minima were reported in South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Michigan, northern Illinois, Indiana, and Ohio.

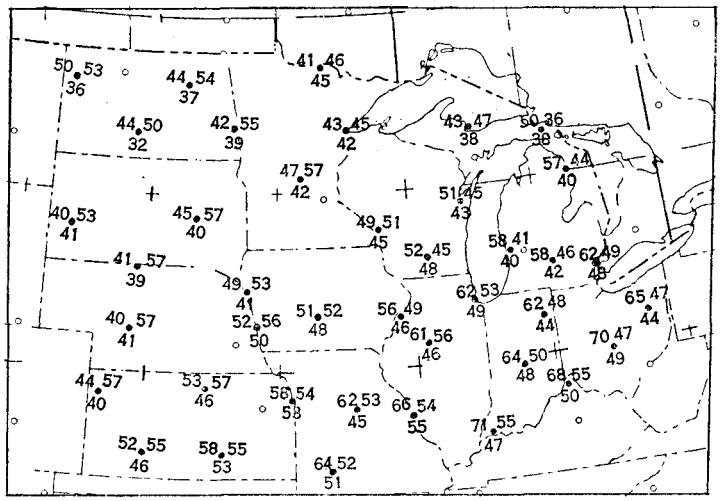

FIGURE 16.—Minimum temperature chart showing the minimum temperature for July 13, 1950 (upper left hand number), minimum temperature for July 14, 1950 (upper right hand number), and the previous record minimum temperature for the month of July (lower number) for selected stations in the northern Plains States and North Central States.

U. S. GOVERNMENT PRINTING OFFICE: 1950

Blank page retained for pagination